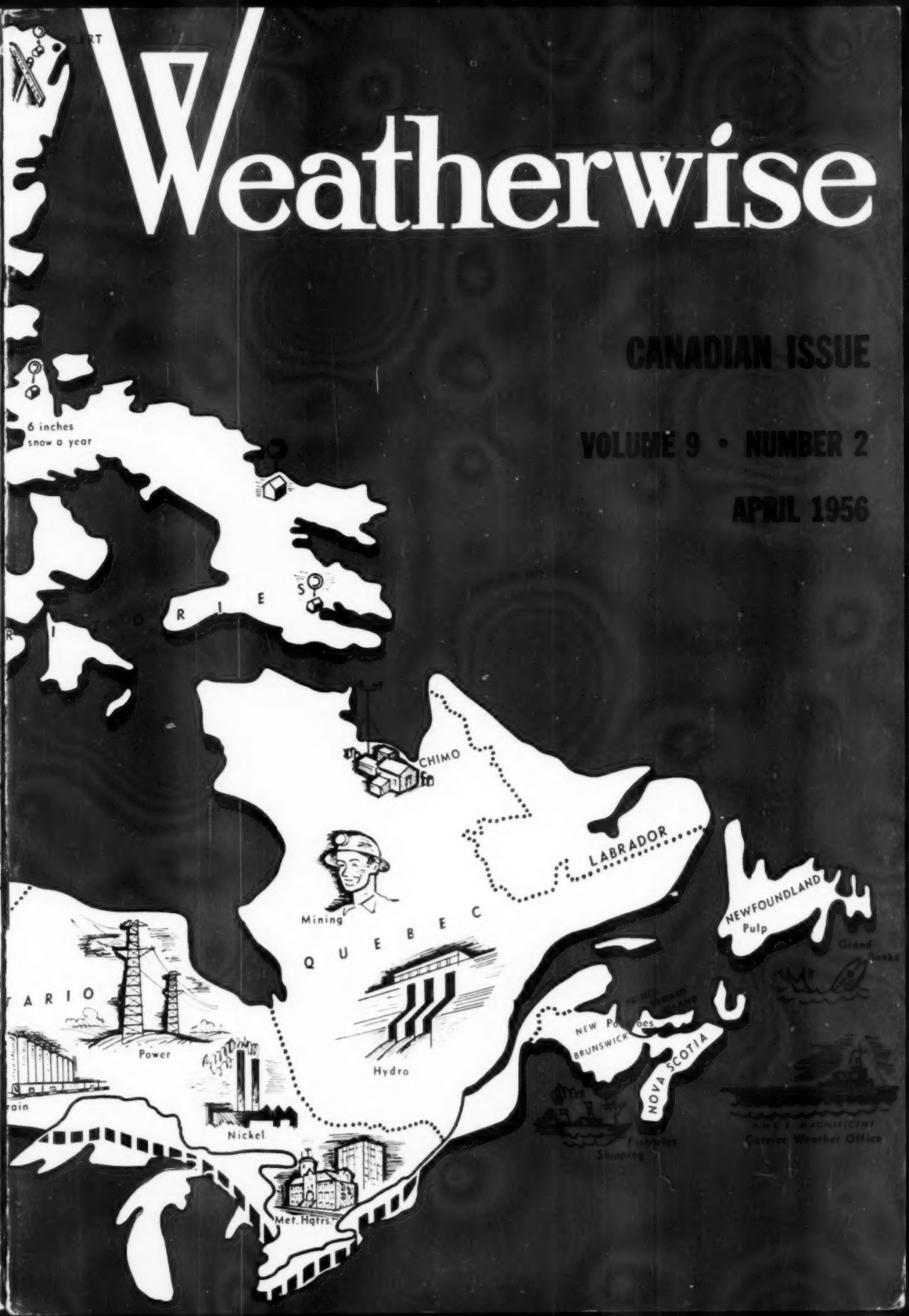
Weatherwise

CANADIAN ISSUE

VOLUME 9 • NUMBER 2

APRIL 1956



"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor* HENRY W. BULKLEY, *Associate Editor*

A Greeting—President Fletcher

IT gives me a great deal of pleasure to extend the greetings of the AMS to our friends and fellow members in the Meteorological Service of Canada. The active participation of meteorologists of this Service provides our Society with representation and experience over a considerable geographical expanse and climatological variety. I feel that such participation across political boundaries is essential to successful continuation of our association.

Our Canadian members have been outstandingly active in advancing scientific and professional meteorology. By submitting technical and scientific papers resulting from research on the meteorology of the North, they have augmented the experiences of our representatives of the temperate and tropical zones. By participating in the activities of the Society—as officers, councillors, and committee members—they have contributed sound advice and the downright hard work which is necessary in running our organization.

Back in 1931 Mr. John Patterson, then Director of the MSC, recognized the great need for intimate cooperation among meteorologists of all the Americas. In his formal address as President of the AMS he said, "The Society, during the short period of its existence, has fully justified the faith of its founders in the need of such an organization on this continent, and of making it representative of both continents with Council members from both the North and South." Mr. Patterson referred to the passage of the Society into a stage of development which he called its "teen age." We have now, I feel, reached the stage of "early maturity," and this has taken place largely because of the sincere support and wholehearted participation in our activities by meteorologists from both sides of the border.

Vol. 9, No. 2 April, 1956

CONTENTS

An Introduction — Andrew Thomson 39
A Short History of the Meteorological Service of Canada 40
Basic Weather Services — D. C. Archibald 42
Public Weather Services — K. T. McLeod 45
Meteorological Communications — A. J. Childs 47
Research and Training in Canada — D. P. McIntyre 49
Trans-Oceanic Aviation Services — R. C. Graham 51
Canada and the WMO 53
Forecasting for Domestic Aviation — F. W. Benum 54
The Climate of Canada 56
Climatological Services — C. C. Boughner 58
The Canadian Arctic — W. Gilmour Clark 61
Weatherwatch 64
Meteorological Instruments — H. H. Bindon 68

WEATHERWISE is published bimonthly for the American Meteorological Society. Office of publication, 3 Joy St., Boston 8, Mass. Subscription is $4.00 per year; add 50 cents for postage to Canada and all countries in the Pan-American Postal Union; add $1.00 for all other foreign countries. Subscription orders, claims for missing numbers, changes of address, and advertising correspondence should be addressed to the society at 3 Joy St., Boston 8, Mass. Editorial offices: Box 216, Princeton, N. J.

An Introduction —

ANDREW THOMSON

Controller, Meteorological Service of Canada

MOST of us in the meteorological field in Canada have been loyal readers of *Weatherwise* during the entire eight years of its existence. Its informative pages have given us hundreds of interesting articles through the regular and special issues. We are accordingly most grateful for the opportunity of assisting with an issue of *Weatherwise* which is devoted to Canadian matters, for we realize with what enjoyment the magazine is read by amateur and professional weathermen in both our countries.

One of the more unfortunate aspects of a modern meteorological service is that, heavy commitments and staff shortages being what they are, the rank-and-file of meteorologists have little opportunity to visit with their contemporaries in other parts of the world. This is particularly true with respect to Canada and the United States where the two countries are so close geographically and yet the amount of exchange visiting is actually very small. I often think that the visiting is done almost entirely by the wrong people. Two or three persons in senior positions do most of the travelling, whereas the practising forecaster who would probably benefit immensely from a tour of weather offices in a neighbouring country gets very little opportunity to travel. It is to be hoped that this issue of *Weatherwise* will compensate in some measure for this deficiency of visiting.

You will find that in this issue the emphasis has been placed on the Meteorological Service of Canada rather than on the climate of Canada as such. This was deliberate. We assume that most readers of *Weatherwise* have a knowledge of the climate of Canada, but for those who wish to refresh their memories we have included articles on this subject and on the Canadian Arctic.

I rather doubt that the casual reader is familiar with the Meteorological Service of Canada although its weather is possibly the one aspect of Canadian life which lies closest to his own field of interest. The reader will discover that we carry on much the same operations in Canada as does the United States Weather Bureau, but we work with one-tenth the budget and with one-tenth the man power, but we hope with equal enthusiasm for weather and weather work.

Canada's geographic position makes her strategically important in several ways. The great-circle routes from the United States to Europe and Asia nearly all touch her. The trans-polar air routes of the future will in many cases pass over Canadian soil. Meteorologically, Canada is a source region for one of the important air masses of the continent—cold Arctic air. Finally, our country, which has an area actually larger than the United States, is meteorologically important to that country because of its position to the immediate north. It is highly desirable from the point of view of both countries that Canada should have a good network of meteorological stations and that the data from

(*Continued on page 70*)

Head Office Building
315 Bloor Street, West
Toronto, Ontario

A Short History of the Meteorological Service of Canada

IT is perhaps significant that the first public weather forecasts in Canada were provided through the courtesy of the United States. In 1873, when both countries were gaining experience in the use of weather reports and synoptic weather maps, the Chief Signal Officer at Washington, D. C., having had some experience in forecasting, kindly agreed to sent to Toronto warnings of approaching storms. Three years later the young Meteorological Service of Canada (M.S.C.) was ready to start on its own. The co-operation demonstrated in 1873 has been sustained in the ensuing years and perhaps no two weather services in the world work more closely together than do the U.S.W.B. and the M.S.C.

On Christmas morning 1839, when Lieutenant Riddell read the thermometer outside a log barracks building at Fort York, he made the first of a series of weather observations that have been continuous since that day. Fort York on the north shore of Lake Ontario was a military camp near the village which grew to be the City of Toronto. Lieutenant Riddell had been assigned earlier in the year to establish a geomagnetic observatory in the colony of Canada, and finding conditions suitable at Fort York had found temporary quarters in the military barracks. As these quarters, which had to accommodate a large number of instruments and items of equipment, also served as living quarters for the six men in his section, it was soon considered necessary to find a more permanent location. The possibility of another armed rebellion made the area in the vicinity of the Fort uninviting. In addition, on the shoreward side the land was swampy and this condition was believed to be part of the cause for a recent severe outbreak of cholera.

After considerable deliberation and negotiation a site was chosen on the grounds of the University of King's College—now University of Toronto—and by September 1840 the new Magnetic and Meteorological Observatory was relocated there. This new Observatory, founded on the initiative of the British Royal Society, had been established as one of a chain of such stations in the British Commonwealth intended for a three-year period of intensive magnetic observations.

Many were the trials of the early directors.

After a difficult three years beset by staffing and financial troubles, which continue to this day, the Observatory was maintained on a year-to-year basis with its meteorological duties assuming a growing importance. In addition to the magnetic and meteorological work, a time service was added and in due course it became necessary and desirable, with confederation of the Canadian provinces in 1867, for the Dominion government to assume control.

The Meteorological Service of Canada was officially established as such in 1871, but the magnetic observations were continued. The period from 1872 to 1880 proved to be one of substantial development. These years saw the beginning of the forecasting service, the distribution of the first storm-warnings, and the beginning of a routine exchange of weather information with the United States. The early forecasters were greatly handicapped by a lack of weather observations. This early period witnessed unsuccessful attempts to secure additional weather reports from such distant points as Hudson Bay posts, and concerted efforts were made to require all grammar schools to take observations. Many of them did provide this assistance and became very useful weather stations.

The distribution of the forecasts, once issued, presented problems as well. Although the chief means of distribution was by telegraph, a unique system was devised whereby the forecasts were displayed on the sides of the trains by means of various discs, but this proved unsuccessful as the trainmen usually overlooked changing the discs. The railway completed its western extension to the Pacific coast in 1885, and the Meteorological Service expanded westward at the same time, leading shortly after to the establishment of weather-reporting stations in the Prairie Provinces and British Columbia.

The area covered by forecasts issued from the Headquarters office expanded gradually. In 1898 a forecast office was opened at Victoria, B. C., and until the Second World War, this office supplied all the public forecasts for British Columbia.

An interest in the upper-air began in the early part of the twentieth century and in 1910 the Meteorological Service of Canada established a kite aerological station just outside Toronto. A weather office was opened in the Grain Exchange Building at Winnipeg in 1918 for the benefit of the grain-growing prairie provinces. The year 1920 saw a new emphasis on flying and with it came the first experiments with pilot balloons.

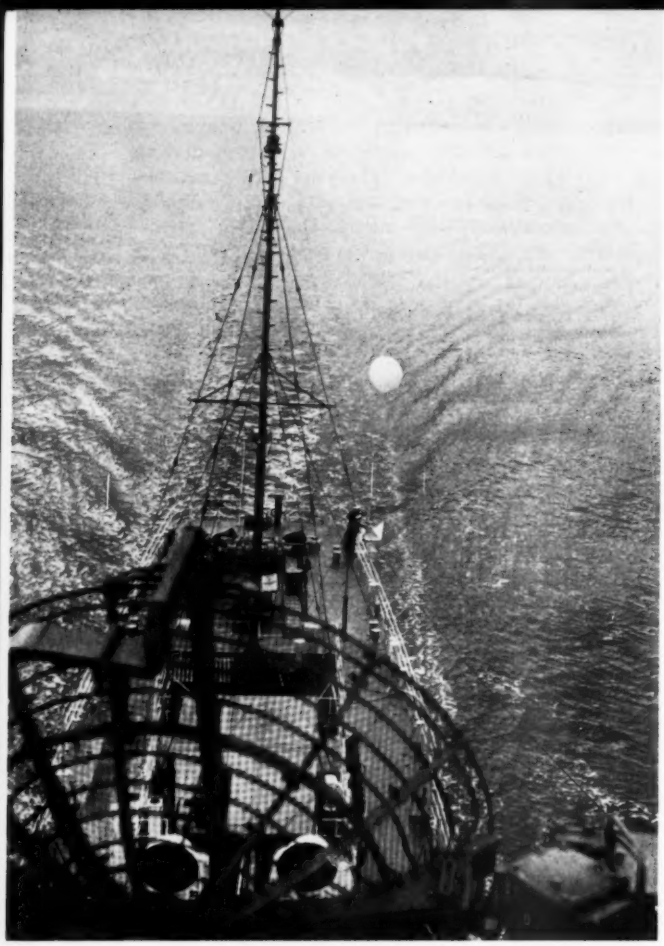
Expansion during the 1930's, while handicapped by the world-wide depression, was greatly stimulated by the introduction of trans-oceanic flights and inter-provincial flights by the newly-formed Trans-Canada Airlines. The new era of air travel necessitated the establishment of aviation forecast offices at a number of points across Canada.

No other period, of course, can approach the expansion rate during the six years of the Second World War. The Meteorological Service might have expanded manifold with purely national demands for service, but when the British Commonwealth Air Training Plan was established on Canadian soil the demands on the Service were increased beyond the greatest expectations. Over 300 meteorologists were trained during this period to meet the varied demands which this unique project placed upon the Meteorological Service. At the same time other wartime operations required extensive assistance—the Ferry Command which flew planes across the Atlantic; the Northwest Staging Route along which American planes were ferried to Alaska; and the general wartime increase in service to the Army, the Navy, and to civilian operations.

The chief feature of the post-war period has been the decentralization of the public weather service. Canada is now provided with weather advice by seven public weather offices, each responsible for a large district. During the past eighty years the simple centralized storm-warning service of 1865 has expanded into a comprehensive broadscale public weather service for the private citizen, for agriculture, business, and industry. At the same time, aviation commitments have been growing at an accelerated pace.

A great deal of emphasis has also been directed in the post-war period to the establishment of an Arctic observing network. In this development Canada and the United States have worked together very closely. More than 20 stations now co-operate to provide information about the meteorology of this little known but vitally important area.

(Continued on page 63)



A radiosonde release from a Canadian weather ship.

Basic Weather Services

D. C. Archibald

Superintendent, Basic Weather Services

As the name indicates, the basic weather section of any meteorological service is of fundamental importance. It provides the observational and in certain cases the experimental, data for the daily forecast routine, for climatological and research studies, and for investigations into instrument design and techniques.

The network of Canadian meteorological observing stations, although growing slowly, is still relatively sparse largely because much of the country is uninhabited. The vast area involved—larger than the United States—presents special problems affecting the maintenance of an efficient network of weather stations, the training of observers, and the collection of reports.

Canada also takes an active part in the collecting of ship observations. Recruiting of weather reporting ships of the Merchant Marine and maintenance of equipment in good order is carried out by Port Meteorological Officers at Vancouver, British Columbia; Halifax, Nova Scotia; and Saint John, New Brunswick. These officers also make courtesy visits to ships of all nationalities to assist the ships' officers in their meteorological reporting program and to give encouragement to them in their meteorological duties. Anemometers have been supplied to a number of ships on the Great Lakes, and these ships when on open water provide regular reports of wind, weather, and visibility.

To encourage weather reporting by ocean-going Canadian ships, an annual "Excellent Award" is made to ships' officers who have participated in the weather reporting program and whose work has been of a high standard. A book on a scientific subject, usually related to meteorology, or to geography, is selected

for the award. It has been found that this award has done much to foster interest among sea-faring personnel in making high-quality meteorological reports.

Inspection and maintenance of land reporting stations is accomplished by a Meteorological Inspection Service which provides an inspector for each of the Air Services districts across Canada, with bases at Vancouver, Edmonton, Winnipeg, Toronto, Montreal, and Moncton. A vehicle is provided to each man for convenience in travelling and for transporting his equipment. In these vehicles the Inspector carries a portable standard barometer, spare thermometers, rain gauges, Stevenson Screens, and perhaps one or more anemometers, as well as a kit of inspection tools and an ample supply of meteorological pamphlets, circulars, and Inspection Report Forms. The Inspectors are regarded as key personnel since the quality of the observations and the written records depend to a large degree upon the thoroughness of inspection and the tact with which the Inspector carries out his duties. As an Inspector is required to check both paid and voluntary stations, many of which are at isolated places, he is confronted with a wide variety of problems that continually tax his wisdom, patience, and ingenuity.

In the course of his travels the inspector is occasionally requested to speak at luncheon clubs, and is interviewed by the Press, so he also doubles in the capacity of a public relations man. The inspector checks all meteorological equipment on each station, doing such servicing of equipment as is feasible in the field. He is thus well qualified to report on any deficiencies of the instrumental equipment and a number of modifications have been made to the instruments as a direct result of such recommendations.

Each year an Inspectors' Meteorological Conference is held at Toronto. The meeting affords an opportunity to discuss field problems with those directly concerned in Headquarters. Considerable time is spent by the group of inspectors in the Instrument Laboratory and Shop, so that the inspectors may become familiar with any new instrumental techniques or new methods of servicing equipment. This direct liaison between the field inspectors and the Headquarters staff is of very great assistance and much importance is attached to this annual conference.

The Canadian upper-air stations are distributed in a network throughout the length and breadth of the country. The exact locations were selected after practical consideration of meteorological requirement, accessibility, transportation, and living arrangements. An attempt was made to space them approximately 400 to 600 miles apart. Thirty-two upper-air stations are operated in Canada, of which twenty-six take rawinsonde observations twice daily, while six take radiosonde observations.

As Canada does not possess sufficient quantities of helium gas, hydrogen is manufactured for inflating the balloons. Since hydrogen mixed with air in certain proportions is highly explosive, considerable attention was given to the development of a low pressure hydrogen generator. This type of generator is now used at all our upper-air stations and has reduced the explosion hazard very considerably.

The tour of duty at a remote station is generally one year, but it may be extended to a second year at the employee's request. Many of the observing stations are completely isolated; at some the only nearby inhabitants may be employees of a fur-trading company or a few Eskimos. Amateur radio, however, is a great morale booster and provides a convenient and interesting contact with other 'hams' and friends back home.

Two radiosonde training schools are maintained at Toronto and Edmonton, where those Meteorological Assistants proceeding to a radiosonde or rawinsonde station receive their training in upper-air observing.

The earliest record of meteorological observations in Canada were barometer and thermometer readings at Prince of Wales, Fort Churchill, Manitoba, where observations were taken in 1768 and 1769 and then discontinued. Continuous meteorological observations have been taken since 1839 in Toronto, Ontario.

The highest observing station in Canada is located on top of a British Columbia mountain midway between Vancouver and Lethbridge at an elevation of 8,000 feet. Although this station has been struck by lightning several times, and during severe

icing conditions the observatory becomes completely encased in a heavy coating of ice from several inches to a foot thick, the personnel working at this station find their assignment interesting and do not mind the isolation or abnormal mountain-summit climate.

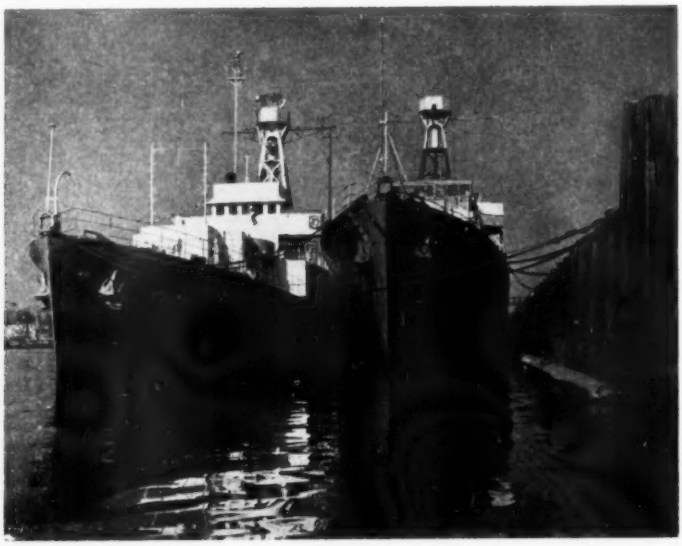
Our most westerly station is located at Snag in the Yukon Territory, almost at the Alaskan boundary; this station also holds the record for the extreme lowest temperature in Canada $-81°$ F. The most easterly land station is Torbay on the east coast of Newfoundland.

The most northerly station is Alert on the northern tip of Ellesmere Island at 82° 30′ N latitude. Alert is one of a group of five Arctic stations jointly operated by Canada and the United States. The central joint Arctic station is located at Resolute on Cornwallis Island, and serves various scientific interests as well as meteorology. All of the Arctic stations from time to time provide bases for scientific expeditions such as geological survey parties, botanical investigations, and wildlife studies.

The meteorological program at these stations consists of two rawinsonde observations daily, two pilot balloons, and eight 3-hourly surface observations of all meteorological elements. Observations of temperature profiles in the sea ice, vertical temperature gradients in the lowest layers of the air, temperatures in permafrost to a depth of 650 ft., observations of physical characteristics of snow, and tide observations are some of the special investigations being carried out.

Access to some of the Arctic stations is by air only and landings may be possible only at certain times of the year. Many and varied are the problems that confront those responsible for seeing that the needed supplies are delivered, that personnel are relieved on time by a staff who will work harmoniously together during the long Arctic night. Good health and the right personality are important as the handful of men at each post must live for months with each other, and with the endless wind and cold, and the loneliness of the Arctic barrens. Surprisingly many Arctic observers, anxious to return to civilization, after a year or so back in civilization seem just as anxious to get out to the Arctic again.

Canada and the United States co-operate closely in the administration of the Arctic stations, sharing the costs and the problems of supply. Each contributes half the personnel, though a Canadian is in charge of each station. The Arctic Weather Station Program is gradually unfolding the secrets of the far North. Meteorological personnel, visiting scientists, and administrative staff are gaining a unique knowledge, and becoming experts on Arctic life, vegetation, geography, and weather.



HMCS Stonetown, on left, is one of Canada's weather ships in the Pacific Ocean.

A weather display beacon atop the Canada Life Assurance Building in Toronto.

Public Weather Services

K. T. McLeod

Superintendent, Public Weather Section—Forecast Services

PEOPLE are curious, and like to be well informed on popular topics of discussion. The weather has probably always been the favorite subject of conversation throughout the world. Most people feel free to open a conversation with it, and to many people whose livelihood and prosperity depend upon it, every change is cause for conversation or concern. The farmer searches the sky for hope of rain, the sailor feels the wind in his bones and checks his weather glass. Construction engineers shift men and adjust jobs to keep in harmony with the present and future weather, and maintenance crews, fire fighters, and public utilities men are constantly watchful for those conditions that bring damage, breakdowns, and disaster.

Not too long ago the farmer, the sailor, and the storekeeper each tried to be his own weatherman, or relied on the local prophet who had some uncanny skill or perchance had made one or more fortunate predictions.

The earliest requests for an organization to prepare a centralized type of public forecast came from the mariners. It was they who took long odds with the storms at sea and all too often found their knowledge and proverbs inadequate.

From a small beginning in 1873, when storm warnings and marine forecasts were first issued, public weather services have grown year by year in scope and number until in 1956 it seems there is no operation or problem on which weather services cannot be of help.

When first questioned, one may think of public weather services somewhat vaguely and recall the early morning comments on the day's weather by radio commentators, the daily weather column in the local paper, or last night's weather rundown on television. It is unlikely that anything much is known about where all this weather information came from, or what type of organization lies behind the endless stream of daily forecasts and information of wide variety that is made available.

Before the war two forecast offices provided all the public forecasts for the populated areas of Canada. The central office at Toronto was concerned with the entire area from the foothills of the Rockies to the east coast and out over the coastal waters of the Atlantic. A smaller office in Victoria, British Columbia, provided forecasts for as much of that province and the adjacent ocean areas as seemed necessary. During the war public forecasting was greatly curtailed, but in the immediate post-war era the interest in weather and greatly increased number and variety of inquiries led to a new type of organization. The public weather services were decentralized. Canada was divided into six Districts each with a single main forecast office made

responsible for providing all public weather services authorized for the District. Later when Newfoundland confederated with Canada a seventh District was formed. The public weather offices, after which the Districts are named, are located at Vancouver, Edmonton, Winnipeg, Toronto, Montreal, Halifax, and Gander. Marine warnings and routine marine forecasts are part of the duties of those offices in which there are marine requirements. At times ships and fishing vessels choose unusual areas of interest and in turn certain offices take on somewhat unusual chores, such as forecasting for the Churchill-Hudson Strait shipping route, or for three fishing areas off the west coast of Greenland.

To meet the localized weather needs of the people and industries in the various parts of the Districts, each was divided into a number of regions. The number of regions was kept to a minimum by close attention to the natural geographical boundaries and local topography in the District. And since local temperature forecasts simply could not be provided for every village, town, and city in each region, although everyone seemed to want them, while the press and broadcasting agencies wouldn't use them, a representative point was selected in each region for which the daily highs and lows are provided. The District map, distributed widely, gives boundaries and names of regions, and on the back provides notes and helpful advice on "How to Make the Most of the Forecast."

As in certain other sciences, meteorologists have their difficulty in getting their thoughts and conclusions across to the user in a clear and concise manner. Weather terms and conditions seem to vary in local usage. Such terms as fair, partly cloudy, and sleet, such qualifying adjectives as generally, mainly, possible, and probable are hard to define and all too often are implied simply as hedging. These terms have restricted use or are not used at all in public forecasts.

One of the chief duties of the forecast offices is the issue of weather warnings. The soldier, sailor, and airman have found that the weather can be a treacherous enemy, in the form of a raging storm at sea, biting cold, or the hidden menace of ice in clouds. Some of the oddities of Canadian weather are widely known by their reputation. The Chinook wind that comes down the eastern slopes of the Rockies raising the temperature 40 degrees in as many minutes, the cold waves and blizzards of the prairies, and the fog banks off Newfoundland, each takes its toll of lives and possessions. Adequate and early warnings of these and other weather hazards are a first-order responsibility of the public weather service, which sees that a warning goes out to each name or number of the users who have expressed their concern over extremes of wind and temperature, rain and snow.

The frequent daily forecasts usually meet the needs of the farmer, the fisherman, the housewife, and the traveller. But those who make major decisions, who fight forest fires, and maintain highways, who service our lines of communication and harvest tender fruits and vegetables, their needs are greater, more specific and of broad concern. For them special advice and forecasts are prepared, suited to their special needs, and relayed on special lines of communication. Frost warnings and daily advice are provided to fruit growers in the Okanagan, the Niagara fruit belt and elsewhere, and shippers of perishable goods have a wide selection of highs and lows of the past and the future to guide them in heating or refrigerating their shipments.

These are the daily tasks. These are the services provided day in and day out, night and day throughout the year. And with time new tasks are being added. Whether it's briefing a TV weather announcer, or preparing for a show of his own, or answering countless calls for personalized advice for the baker, the ice-cream vendor, or the anxious mother, the public forecaster is a central source of weather advice, and a king-pin in the community.

Back of the forecaster, the field office and their organized pattern of operations is a central co-ordinating guide, the Headquarters Public Weather Section. Here new or unusual requests are considered, new schemes for more efficient service are developed, and new procedures devised to meet newly approved demands. The variety of Canadian demand, the facilities and personnel available, and the constant adjustment to meet changing situations across the country are under constant survey. Modern trends in applied meteorology and new developments in dispersing

(*Continued on page 50*)

A unit of the Canadian Weatherfax System receives weather charts by wire from Analysis Center.

Meteorological Communications

A. J. CHILDS, *Superintendent, Meteorological Communications*

IT is generally realized that a good communication system can be the very backbone of an organization, and nowhere is this more obvious than in a weather service. From its first primitive beginning in the pioneer days to the present extensive networks, the Canadian meteorological communications system seems to have used almost every conceivable type of communications at one time or another. The endless pressure of urgency has seen the dog team and the Indian runner, the railway and the airplane, each play its part, but the old faithfuls, as elsewhere in the world, are the telegraph, the radio, and the teletype machines.

Exposed to the elements that pass in majestic variety, continually testing the ruggedness of the lines of communication, Canada presents real problems to those responsible for getting the weather reports through on time. Although many areas in the United States have climates with extreme temperatures, winds, rain and snow, it is likely that the thousands of miles of Canadian lines experience more of such extreme climates, and have longer stretches of isolated, harder-to-get-at vital lines of communications.

The Canadian Meteorological Service operates a 28,000 mile teletype network made up of two trans-continental lines and many feeder lines to the north and south. After many months of planning and investigation a national facsimile network went into operation in 1953. This 6,000 mile communications system using landlines and radio transmissions now actually brings the latest weather maps and special charts directly into nearly all Canadian forecast offices from a

Central Analysis Office and the District Forecast Offices.

Operated under lease by the Meteorological Service, the teletype and facsimile landline circuits and equipment are owned and serviced by the two major railway companies in Canada, the Canadian Pacific and the Canadian National Railways.

Despite the great distances, the severe climate, and the rugged terrain involved, a high degree of efficiency is maintained, and much credit must be given to the workaday maintenance and operating personnel who keep this far-flung system in first rate service.

Two areas in Canada have especially rough terrain—the province of British Columbia and Northern Ontario. Establishing and servicing lines in such areas are costly operations. The smaller population and light telegraph traffic in these locations makes it uneconomical for private telegraph companies to operate communications systems that might be used as feeder lines. However, a coast-to-coast micro-wave system is now under construction and a number of sections are in operation.

Since procedure and equipment are similar in Canada and the United States, the exchange of weather information between the two countries presents no problem. The same general principle of uniformity applies in the world-wide exchange of weather information, and more and more time is being set aside on Canadian circuits for the transmission of weather information from Europe and Asia as new inter-continental airline routes are developed.

The creation of the publicly-owned Trans-Canada Airlines in the late thirties did much to stimulate the completion of a coast-to-coast meteorological communications circuit. A chain of aviation forecast offices was established across the country in 1938, and it was immediately necessary to link them together with teletype circuits. During the war years demands on communications increased greatly, and a second coast-to-coast chain of connecting teletype circuits was necessary. Even with two parallel circuits the needs of our expanding Service can now be met only with increasing difficulty.

The facsimile system was developed to provide a better weather service with fewer personnel. As it has become incorporated into the District and local procedures, its value is becoming steadily more apparent. The system was set up so that charts prepared by the Central Analysis office at Montreal are made available as soon as possible to all connected forecast offices. A high degree of uniformity in weather analysis results and many offices rely entirely on the facsimile for their weather maps. In addition, the network is broken down at scheduled times into five regional networks, permitting the regional forecast offices to transmit locally prepared charts to the satellite dependent forecast offices within each region.

Facsimile now provides the regional and dependent offices with more useful and detailed analyses of upper air and surface data than could possibly be prepared locally. One direct result of this additional information has been that high-level flying operations can be provided with weather service by any forecast office.

Every effort is made in Canada to use the latest in modern communication equipment. Engineers are presently studying the application of the magnetic drum principle for relay work at our largest teletype relay center at Montreal Airport. The magnetic drum is an electronic device whereby traffic from several circuits may be simultaneously recorded. The system has all the advantages of magnetic tape. The observational data or messages are then relayed from the storage drum as required.

Radio-teletype and radio-facsimile circuits carry weather information to isolated stations such as Goose Bay and Churchill, and as far north as Resolute in the Arctic. Special switching arrangements, ample automatic equipment, two-deck tables for teletype machines, and a host of other aids have been developed to assist teletype staff in the performance of their work. Continual research is directed to the facsimile processes to ensure that the highest standard of performance is obtained from the equipment.

The Canadian Meteorological Service is fully aware of the importance of good communications to national and international meteorological services and every effort is and will be made to maintain a high degree of efficiency in that field.

Research and Training in Canada

DR. D. P. MCINTYRE, *Assistant Controller, Research and Training*

THE University of Toronto, Department of Physics, offers a graduate course in Meteorology, leading to the Master's degree. This course is given with the co-operation of the Canadian Meteorological Service which provides the lectures in theoretical and practical meteorology as well as the facilities for the synoptic meteorology laboratory and for research. The course is given only to qualified graduates who have an honours degree in mathematics and physics. About 200 students have obtained their Master's degree under this arrangement during the past 20 years.

After graduation, the students receive further training in the techniques of synoptic analysis and forecasting before proceeding to a six-month period of contact-training at the forecast office.

A course for meteorological officers, dependent forecasters, and meteorologist-instructors is given by the staff of the Canadian Meteorological Service to university graduates who have at least 24 (very frequently up to 50) semester hours of undergraduate courses in physics and mathematics at the calculus level. Professional meteorologists in this category serve the needs of military training and of smaller weather offices in Canada. After further university training in mathematics and physics, these graduates often qualify for the post-graduate course leading to the Master's degree.

During World War II a great impetus was given to our meteorological training when Canada undertook to provide weather service for the British Commonwealth Air Training Plan. Meteorologists, forecasters, and instructors were needed in large numbers to fill the requirements of the Air Training Plan. Nearly 400 meteorologists were trained from 1940 to 1945. Since the war, 200 additional meteorologists have been trained in the meteorological officer category. Many war-trained forecasters returned to their peace-time occupations. Some could not meet post-war standards, but many remained in the Canadian Meteorological Service to form the backbone of the present forecasting service.

In spite of this year-round professional training program, the shortage of qualified professional meteorologists continues as a result of the growth of civil and military requirements for meteorological services. There is a general shortage of science graduates who are interested in post-graduate study in meteorology. Also employment opportunities for professional meteorologists in Canada are almost entirely confined to the government services.

McGill University at Montreal, with a meteorologically-minded geography department under Professor F. K. Hare and a cloud physics research group under Professor J. S. Marshall, is the only other university in Canada to provide facilities for post-graduate study in meteorology. Some universities offer elementary undergraduate courses in meteorology and climatology for general science or geography students.

An important function of the professional training section provides refresher training and field training for the practising forecasters. A few short refresher courses have been given. Refresher lectures are delivered periodically to conferences of meteorologists who are in charge of forecast offices. Frequent Technical Circulars and Training Circulars designed to acquaint forecasters with new developments and with the results of current researches in progress at other stations are published. A scientific service with many of its employees on shift duties requires a full program of field training and refresher training. Full development of this program, however, still awaits the easing of staff shortages so that more qualified personnel can be made available to take part in training activities.

Meteorological research has been carried on in Canada by the Meteorological Service for many years. For example, Dr. E. Wendell Hewson achieved international recognition for

his work in the field of air pollution. Dr. Bernhard Haurwitz, while in Canada, made significant contributions in the field of large-scale atmospheric motions. More recently, Messrs. C. M. Penner, A. M. Crocker, and Dr. W. L. Godson developed the technique of frontal contour analysis which had led, in Canada, to the adoption of a three-frontal, four-air mass atmospheric model for operational analysis. Dr. Godson has, in addition, made significant contributions in the fields of dynamic meteorology and radiation.

Today, the healthy growth of meteorological research is evidenced by the division of research activities between the Meteorological Service and several Canadian universities. In the Physics Department at McGill University, Prof. J. S. Marshall and his "Stormy Weather" Group have done outstanding work in the fields of cloud physics and radar weather analysis. In the Geography Department at McGill, Prof. F. Kenneth Hare leads a group in studying, among other things, dynamic climatology, with special emphasis on the Canadian Arctic. Readers will remember Prof. Hare's popular book, "The Restless Atmosphere." At the University of Saskatchewan, Prof. B. W. Currie conducts researches in auroral physics, and at the University of Alberta, Prof. E. H. Gowan is internationally recognized for his work in the fields of atmospheric ozone and radiation.

The Meteorological Service itself has continued and expanded its efforts in research. R. H. Douglas is attached to Prof. Marshall's group at McGill, and H. W. Baynton has been studying the meteorological aspects of atmospheric pollution in the Detroit-Windsor area under the auspices of the International Joint Commission. Under the direction of Dr. Godson, the Research Section at Toronto is actively conducting researches in a number of directions: on methods of numerical weather prediction, aircraft condensation trails, aircraft turbulence, upper wind forecasting, radiation climatology, and on the basic properties of radiation instruments. Work on jet streams at high latitudes is continuing under Dr. D. P. McIntyre. Another project involves the development and application of techniques designed to improve the timing and accuracy of short-range terminal forecasting for aircraft operations.

Currently, too, planning has been under way for the Canadian Meteorological program during the International Geophysical Year, 1957–58. This program will emphasize studies of the dynamic and thermodynamic features of the general circulation at middle and high latitudes. Special high-level radiosonde flights will be made twice daily at a network of six stations near the 80° W meridian, from Moosonee (51° 16′ N) to Alert (82° 31′ N). Measurements of atmospheric ozone concentrations will be made at Moosonee, Resolute, and Alert; the long and short-wave components of the radiation balance will be determined at Moosonee. At Resolute (74° 43′ N, 94° 59′ W) a concentrated program will include four high-level rawinsonde flights per day and the measurement of all the components of the energy budget at ground level. Hopes are high that these series of measurements will contribute significantly to our knowledge of the general circulation.

CLIMATOLOGICAL ATLAS

The "Climatological Atlas of Canada," published in 1953, is a practical, spirally bound Atlas of 253 pages containing 84 climatic maps of Canada. The maps and text are arranged into sections dealing with temperature, humidity, wind, snow, rain and sunshine. Sun altitude tables are shown along with hythergraphs for selected stations. The Atlas was prepared by M. K. Thomas of the Meteorological Division, and is obtainable from the National Research Council in Ottawa, Ontario, Canada, at $2.00 a copy.

Public Services (*Continued from page 46*)

weather advice continually challenge and inspire the Public Weather Section. Weather control, with its many implications, television and radio, private meteorology, educational material for schools and the hobbyist, all these are demanding and yet each plays its part in the over-all development of meteorology.

People are curious. They will always want and need the latest weather. The future promises to be one of steady, perhaps surprising, but certainly stimulating development in the field of Public Weather Services.

A briefing of Navy airmen aboard HMCS Magnificent by a M.S.C. forecaster.

Trans-Oceanic Aviation Services

R. C. GRAHAM, *Superintendent, Trans-Oceanic Aviation Services*

MOST major international aerodromes have been built to serve nearby major cities. But in northeastern Newfoundland the town of Gander has been created in the wilderness, solely to serve an international aerodrome. The reasons behind this reversal of the usual cause and effect underlie much of the role of Canada in serving international aviation.

Newfoundland, the most easterly land in North America, is situated near the great-circle tracks between major cities in eastern North America and western Europe, and was destined to be the jumping-off place for flights to Europe, and the first point of landing for flights from that continent. Canada undertook the provision of meteorological service in Newfoundland (long before it became a Canadian province), and in 1937 a small group of Canadian meteorologists set up a forecast office at the seaplane base at Botwood. Since then, Canada has been continuously providing meteorological service to trans-oceanic aviation.

The present triad of main meteorological offices—Gander, Dorval (Montreal), and Goose Bay in Labrador—serving trans-Atlantic aviation, grew up in the late thirties and early forties. In the years immediately after

World War II, trans-Pacific operations over the North Pacific to the Orient, and through the South Pacific to New Zealand and Australia, gave rise to requirements for forecast services at Vancouver. Operations were developed from eastern Canada to Bermuda and the Caribbean, requiring forecasting services from Malton (Toronto) and Dorval (Montreal).

Recent years have seen the inauguration of regular flights from Montreal to Mexico, Montreal to South America, and Vancouver to Mexico and onward to South America. The last year has seen the beginning of scheduled commercial air services across northern Canada, connecting cities in western North America with cities in northwestern Europe. In November 1954, a scheduled service from Los Angeles to Copenhagen via Winnipeg and Greenland was opened, and in the spring of 1955 regular service began between Vancouver and Amsterdam via Greenland.

Canada, by virtue of location, extent, and climate, is an area where requirements for meteorological service are much greater in proportion to population than in most parts of the world. Accordingly, the organization and procedures for serving international aviation in Canada have been conditioned by the necessity of meeting extensive requirements for service with limited manpower resources.

In Canada, forecast offices serving transoceanic aviation are in all cases multiple-purpose offices serving also the requirements of one or more of the general public, marine interests, or continental aviation. Duplicating equipment permits one plotted and analyzed map to be reproduced for use by several forecasters simultaneously.

Distribution by facsimile of charts prepared at the Canadian Central Analysis Office at Montreal was started in August 1953 and has already paid substantial dividends to international aviation. The meteorological services requested at Winnipeg and Vancouver for the flights to Europe via Greenland could not have been provided without fascimile—there was just not sufficient staff available to extend the chart programs at those offices to cover the extra area. The increasing exploitation of facsimile will enable the M.S.C. to continue to meet the expanding needs of international aviation.

A full description of forecasting procedures would require an office-by-office exposition. Although there is much in common between the procedures used at various offices in Canada, flexibility must be allowed owing to the widely different geographic, meteorological, and operational considerations at different locations. A few highlights must thus suffice.

The trans-Atlantic offices use charts covering North America, the North Atlantic, and most of Europe, on a conformal conic projection, with scale 1:12.5 million. Upper-air charts, current and prognostic, are integrated with each other and with surface charts by thickness analysis. Analysis is carried out regularly up to 500 mbs at Gander and to 200 mbs at Goose and Dorval. Dorval also analyzes up to 100 mbs for special requirements.

Prognostic charts for flight forecasts are composite: that is, instead of representing future conditions over the entire area of the chart at a given instant, conditions are represented at each point of the chart as they would be expected to be encountered by an aircraft departing at a given time and flying at a given speed over the route or routes for which the chart is prepared.

Flight forecasts for international flights are ordinarily presented in ICAO cross-section form, with appropriate current and prognostic charts. Procedures for supplying forecasts and other meteorological information vary from office to office depending on the volume and pattern of operations. If flights are few, it is most efficient to provide individual forecasts for them on request, and to provide in-flight meteorological information with respect to individual flights. If flights are many, forecasts are mass produced at scheduled intervals, for use by all flights on given routes in the period covered, and meteorological information for aircraft inflight is provided in bulk to operator's local representatives, who can then select what they consider necessary to send to individual aircraft.

Paradoxically, the improved abilities of aircraft to cope with weather have been accompanied by increasing rather than decreasing requests for meteorological services. Changes in aircraft design have brought about changes in emphasis in requirements for meteorological information, but the net effect has been

an increase, not only through sheer increased volume of operations, but also through larger requirements arising from longer flights to more distant places.

For example, it might have appeared that requirements at Gander would decline as aircraft were developed capable of flying between the major population centres without landing at Gander. However, in the year ending March 1955, some 12,000 aircraft stopped at Gander—about the same as the total number of trans-Atlantic crossings on all routes in 1950. Moreover, approximately 20,000 trans-Atlantic flights, most of those crossing the Atlantic, received inflight service from Gander.

As for the future, one can see only a continuing increase in the meteorological services required of Canada for trans-oceanic aviation. Immediate problems are: the increasing volume of traffic on the well-developed routes; the requirements of new routes over the Arctic and sub-Arctic areas; and the new demands created by jet transport aircraft, in addition to the continuing requirements of piston-driven aircraft.

Canada and the WMO

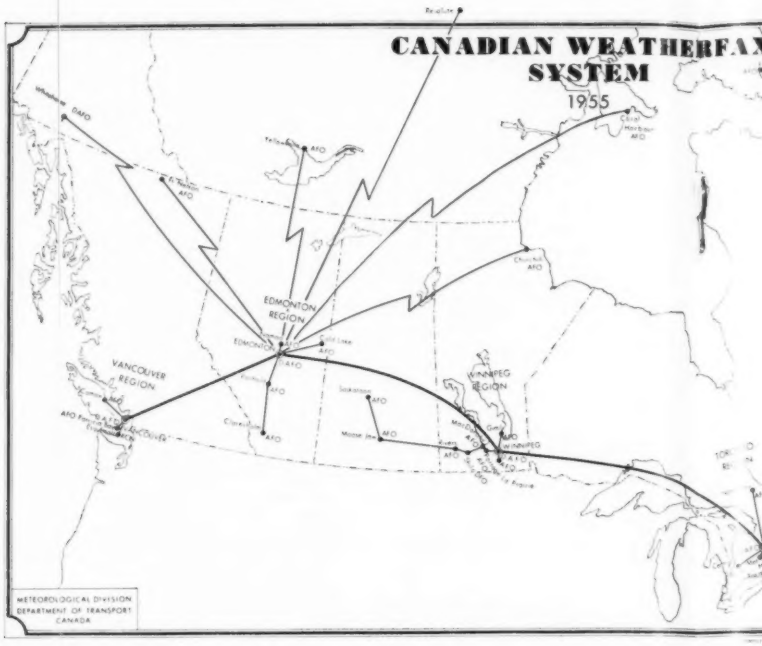
METEOROLOGY is one field in which a policy of isolation is virtually impossible. International co-operation between weather services, particularly in exchanging data, has been essential since the beginning of organized meteorological observing. As far back as one hundred years ago the nations of the world were co-operating in a united attempt to get ship reports from the oceans for their mutual use.

The Meteorological Service of Canada has taken an active interest in international meteorology ever since the inception of the Service in 1871. Even the heads of the M.S.C. have approached their position with an international viewpoint. The present controller, Andrew Thomson, came to the M.S.C. after extensive scientific experience in Samoa, New Zealand, and the United States. His predecessor, John Patterson, was Imperial Meteorologist for the Government of India before joining the M.S.C. Both are native Canadians. Before that the directors of the Service had been British.

Canada made her first direct contribution to international co-operation in weather during the 1870's when she exchanged data from seven Canadian weather stations for fifteen weather reports from the United States. Her first report to an international gathering was made in 1882 when Director C. Carpmael sent a complete report on the Canadian Weather Service to a convention of meteorologists at Copenhagen. This International Committee was the forerunner of the International Meteorological Organization. Canada sent her first delegate, R. F. (later Sir Frederick) Stupart to a world convention in Paris in 1896. Since that date she has been an active participant in the growth and development of the IMO and the present World Meteorological Organization.

Canada has been host to the Technical Commissions of the IMO and the WMO, first in 1947 and again in 1953. She has twice provided the President for the Commission on Instruments. W. E. K. Middleton held the position briefly in 1945–46; Dr. J. Patterson, ex-controller, was President from 1946 until 1953. Canadian meteorologists are members on each of the eight Technical Commissions.

The present controller, Andrew Thomson, has continually taken a keen interest and an active part in international weather matters. He is at present a member of the Executive Committee of the WMO and also president of Regional Association IV (North and Central America).



Forecasting for Dome

F. W. BENUM

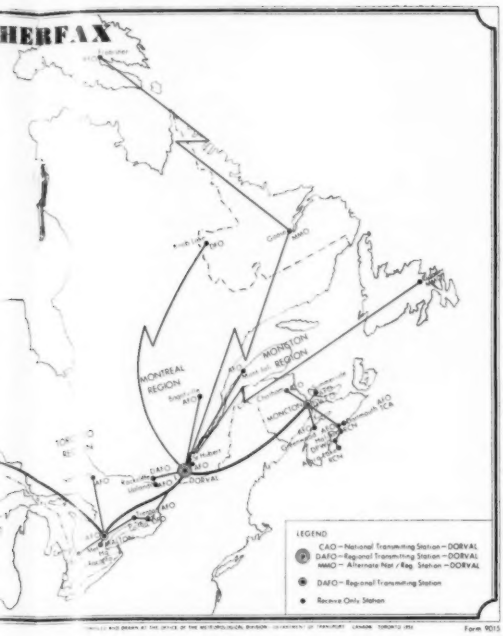
Superintendent, Continental Aviati

AVIATION is performing a major role in the rapid expansion of Canada's economy; the Meteorological Service of Canada plays a fundamental part in assisting Canadian aviation with that expansion. The continuing growth of Canada and the defence of Canada still depend to a large extent upon the airplane. But the safe and efficient use of the airplane depends upon full knowledge of the weather.

Prior to the advent of the airplane, the growth of Canada was handicapped by the high cost of constructing roads and rail. Consequently Canada's populated areas grew up along the narrow ribbons of rail which extend from coast to coast near its southern border. To the north lay a vast and unexplored area of great potential resources. Only a few explorers, trappers, and traders ventured northward into the unknown.

The airplane presented great possibilities for Canada. Even before the development of commercial aviation, it began to play its part. To the adventurous bush pilot of thirty years ago must go much of the credit for exploiting this means of transport to explore and open up new areas. Largely as a result of his daring, the vast potential of Canada's large land mass has become known and is rapidly being developed.

To the aircraft designer, manufacturer, and operator, there are many weather problems peculiar to Canada. In addition to the usual difficulties presented by low cloud, fog, turbulence, and wind, Canadian aviation must contend with temperatures ranging from almost tropical heat to intense Arctic cold, frequent and heavy icing conditions, blizzards, snow-covered runways, and frozen lakes. In the early days lubricants would often congeal, controls would not work, brakes would not hold. All these problems had to be solved. Procedures as well as aircraft construction had to be modified to operate in Canadian weather conditions. The bush pilot flew by the seat of his pants and took his chances. Some still do. But the development of safe and efficient scheduled and un-



Domestic Aviation

V. BENUM

ntal Aviation Weather Services

scheduled commercial aviation had to take full cognizance of our weather.

The birth of Trans-Canada Airlines in 1937 led to the establishment of forecast offices at key points, with weather observing stations at intermediate points along the airways. As Trans-Canada Airlines and other operators developed new routes and expanded their operations northward to the Arctic Circle, and beyond, many new weather observing stations had to be opened up.

Trans-Canada Airlines and Canadian Pacific Airlines are the major air carriers in Canada. Trans-Canada Airlines operates the main service between the larger cities and routes to the United States, Europe, and the Caribbean. Canadian Pacific Airlines operates over a large number of routes in western and northern Canada in addition to its heavy schedule of trans-Pacific flights, Mexican and South American services, and its recent new route over the polar regions to Europe. A large network of feeder lines is operated by companies such as The Maritime Central Airways, Pacific Western Airways and others. And, there is still the bush pilot. Some of these operators have many aircraft; other smaller companies and individuals have only one, two, or three aircraft.

In addition to the commercial operators, many federal and provincial government departments, as well as many large companies and other agencies, operate fleets of aircraft for an almost endless variety of purposes. The red-coated Royal Canadian Mounted Policeman has almost entirely abandoned his horse and taken to modern means of transport, including the airplane. Forestry departments spot fires from the air and transport men and fire-fighting equipment. Aircraft are used extensively for pest control. Helicopters move men and materials to inaccessible spots, particularly in mountainous areas.

Then there are the private pilots operating their own aircraft. Many of these in Canada and large numbers from the United States enjoy the virgin hunting and fishing grounds of northern Canada.

The Canadian Weather Service has the responsibility for providing all of these operators with the weather services they need.

Owing to the free and extensive movement of aircraft between the United States and Canada, it is imperative that both countries use similar procedures for providing weather service. This need was recognized many years ago by both the United States Weather Bureau and the Meteorological Service of Canada, and close liaison has been maintained over the years in the development of procedures. Although there are still minor differences, the basic methods are the same. An American pilot visiting Canada will find the weather services very similar to those at home.

For aviation purposes, Canada is divided into ten areas with each area having a principal forecast office which is responsible for ensuring that all the aviation weather requirements within the area are met. The District Aviation Forecast Office issues aviation forecasts four times daily on a routine basis. Special flight forecasts are issued to

(*Continued on page 66*)

The Climate of Canada

CANADA'S climate like its people cannot be easily or simply described. A country which offers such a wide variety of scenery and grandeur, which has such vast prairie areas, mountain ranges, arctic lands, and extensive coasts must inevitably experience many types and extremes of climate. Probably no other country in the world can match the variations that arise in a year of Canadian weather. And of course, such variations offer a wide choice with definite advantages and disadvantages.

Although an impression may be gained that the Canadian climate is a rugged one and that its residents must suffer prolonged cold, excessive wind, and deep snow, there are many resemblances between the climate of Canada and that of much of the United States. The Great Plains extend far to the north and to the south from the common border, and the coastal climates are not too dissimilar. The most southern part of Ontario is in the same latitude as northern California. The blizzards and heat waves of the Prairie provinces are experienced in the Dakotas and other north-central states. Canada, too, feels the impact of tornadoes in the middle west and at times suffers from the same hurricanes that bring disaster to the United States.

The chief physical features of the continent are found in both countries. To the west the great Rocky Mountain chain thrusts snow-capped peaks into the prevailing westerly winds and produces marked differences in climate between the coastal regions and those to the east of the mountains. In the east the Appalachian chain extends northeastward as a scenic highland through the Gaspe Peninsula and even into Newfoundland, and the Canadian Maritime provinces have a climate that is a northern extension of that of the New England states.

Other than the mountains to the west no prominent physical features are present to dominate or produce sharp divisions to the Canadian climate. There are, however, because of the tremendous expanse of land, substantial differences in the local area climates that seem to blend gradually with each other.

The central portion of the country has a strongly continental climate. Here the three prairie provinces, Alberta, Saskatchewan, and Manitoba, hold a reputation for bumper crops of hard Canadian wheat. Here also are born the western blizzard and the Chinook or "snow-eater." Although the impression is general that the Canadian prairies are a nearly level plain, the land slopes gently upward to the west and south and tends to produce a mild form of up-slope climate.

Almost unaffected by the moderating effect of the oceans, this part of Canada experiences a truly continental climate, with cold dry winters and summers with showers and ample sunshine. The reputation held by the prairie provinces for prolonged cold, and brief fitful summers with "three months poor sledding," is belied by the records for extreme high temperature and hours of sunshine easily maintained by prairie observing stations.

About forty inches of snow will fall on the prairies a year, but the amount of snow is quite variable from year to year. Summers are warm to hot with a July mean temperature from 65° to 70° and the daily range of temperature in both summer and winter is often large. Although the total precipitation for the year is, as in the north-central states, relatively small and generally under twenty inches, fortunately most of it (about 70 per cent) falls in the summer growing season. Farther north in the Peace and Mackenzie River districts and in northern Manitoba and Saskatchewan summers are cooler, but still surprisingly warm for that latitude. The long days, the shelter of the Rockies, and the continental effect lead to July mean temperatures of about 60° with extreme temperatures such as 103° at Fort Smith, Northwest Territories, and 95° at Dawson and Mayo.

About 60 per cent of Canada's 15 million people live in the St. Lawrence Valley and the southwestern Ontario-Great Lakes area. This part of the country has a predominantly continental climate with cool to cold winters and hot summers. Snow is plentiful in the St. Lawrence area, with eight feet generally, while Montreal averages ten feet and the ground is usually snow-covered throughout the winter from December to March. Eastern

Canada, in fact, is the snowiest region of America outside the mountains. For comparison average amounts in eastern United States run from five feet in New York State to about three feet in parts of Pennsylvania and six feet near the Lakes.

Winter sports are popular with temperatures in the Montreal area averaging about 15° and extreme low winter temperatures of 30° to 35° below experienced. In recent years the trend to milder winters has brought concern to resort owners, but the persistent snowcover and only occasional mild spells give residents a straightforward winter without the tendency to drabness of a mostly bare, come-and-go snow season.

Up-river in southwestern Ontario the daily weather is considerably modified by the low latitude and the presence of the Great Lakes. This part of Ontario enjoys a peninsular type climate with a long frost-free season (Toronto averages 165 days), and ample precipitation evenly distributed throughout the year.

Summers in these Ontario and Quebec areas are warm to hot and, at times, humid, depending on the direction of the winds which may bring moist air from the Gulf of Mexico or cooler more comfortable air from the west and north. Autumn is a pleasant season: long, warm and enjoyable.

To the east the Maritime Provinces of New Brunswick, Nova Scotia, and Prince Edward Island have a climate that is less moderate than the name implies. The prevailing weserly winds are mainly from the interior and bring warmer summer weather and cooler winters than would be expected. Halifax on the coast has a mean winter temperature of 23° and summers may bring 90° readings; Moncton, inland in New Brunswick, gets six feet of snow, extreme lows near 30° below, and in summer from June to September the average highest reading is in the moderate eighties. Here the precipitation is a reasonable forty inches well distributed over the year, and abundant crops of fruits and vegetables, especially potatoes, respond to the favourable growing conditions. Although many eastern Canadians and Americans seek relief from the intense heat of their inland homes in the resorts of the Maritimes, the converging tracks of central North American storms assure frequent change and ample variety to the passing weather.

British Columbia, like Washington and Oregon, has two distinct climates. Briefly they are—mild rainy winters and warm sunny summers with little rain. The coasts are ice-free and occasionally foggy. On the western slopes of the mountain ranges the moist air from the Pacific leads to heavy rainfall and deep snow. The prevailing westerly winds also bring large differences in precipitation to places on opposite sides of a rise of land and here the records for Canadian precipitation are held with Henderson Lake, B. C., reporting an all-time high rainfall of 251.30 inches. Favored spots have 250 or more frost-free days and a tourist trade flourishes while the moderate climate offers a real inducement to Canadians in the interior to retire in B. C.

(*Continued on page 70*)

A Rocky Mountain weather post in British Columbia.

Climatological Services

C. C. BOUGHNER, *Superintendent of Climatological Services*

IN Canada, the steadily growing number of inquiries for weather and climatic information during recent years is indicative of the marked increase in public interest and knowledge of various weather elements as they apply to human activities and operations. Accompanying this increase in public interest has been a pressing need for climatic data in connection with the great industrial development in southern Canada, the demand for aviation weather statistics for both civilian and military planning, and the requirement for weather data as exploration and settlement push into the vast expanses of northern Canada.

Climatological Services of the Canadian Meteorological Division have attempted to meet their expanding obligations by a modest increase in the personnel of the section, as well as by the introduction of new techniques and procedures for handling weather statistics. The most noteworthy of the new procedures was the introduction in 1950 of a machine program for handling weather data. The climatological staff attached to the headquarters office of the Meteorological Division now numbers 45, of whom six are professional meteorologists.

Branch climatological offices are maintained at Victoria, British Columbia; Edmonton, Alberta; Regina, Saskatchewan; Saint John, New Brunswick; and Torbay, Newfoundland. In the province of Quebec, the Department des Ressources Hydrauliques at Montreal cooperates with the Meteorological Division by performing the same function as a branch climatological office. These branch offices serve as collection centres for the meteorological reports in their respective districts and carry out prescribed routine climatological duties of a local nature. They also prepare various preliminary summaries which are submitted to the Headquarters office each month for use in connection with the routine publications of Climatological Services.

Climatological statistics are obtained from the day-to-day observations of the weather as provided by conscientious and painstaking observers located at representative points throughout the country. The weather observing network in Canada at the present time consists of 1,517 stations. At 247 of these stations observations are taken at hourly, three-hourly, or six-hourly intervals for transmission by telegraph or radio to the various forecast offices for use in providing public and aviation forecast services. A complete record of these observations is maintained on official report forms and once a month these forms are mailed to Climatological Services at Head Office. Some 857 "climatological" observers record extremes of temperature, measure the precipitation daily, and keep a log of general weather conditions. At an additional 413 stations precipitation only is recorded daily.

Most of the observers at the climatological and precipitation reporting stations serve on a co-operative basis with the Meteorological Division supplying the instruments free of charge; the observer takes the observations without remuneration and sends in a report each month. The great majority of co-operative observers are keenly interested in the weather records and take pride in submitting complete reports each month. Many of the climatological observers have taken observations for a period in excess of ten years and have contributed greatly to our general knowledge of Canadian climate.

In addition to the surface reporting stations the Canadian Meteorological Service maintains 32 radiosonde stations, 26 of which are equipped with rawinsondes. In addition there are 44 pilot balloon reporting stations. Upper-air reports from all these stations are received in Climatological Services.

Each month many thousands of individual report forms and charts are submitted to the Climatological Section from all parts of Canada. These reports are checked, mean values computed, and frequency tabulations prepared for the publications of the Section. The first report distributed is a summary of pressure, temperature, humidity, and precipitation, which is prepared from reports re-

ceived by telegraph or radio from 41 selected Canadian stations. This report is broadcast by short-wave radio and forms part of the international "Climat" broadcast. A series of four charts dealing with temperature, pressure, and precipitation is prepared during the first week of the following month and transmitted over the facsimile circuit to all forecast offices in Canada for local distribution.

Major publications of the Climatological Services include the *Monthly Weather Map* and the *Monthly Record of Meteorological Observations in Canada*. The *Monthly Weather Map* contains temperature, precipitation, and sunshine data on a monthly basis for more than 1000 stations in Canada. The *Monthly Record of Meteorological Observations* contains daily statistics on temperature, precipitation, and sunshine for most of the weather reporting stations in Canada along with the mean values of the various other meteorological elements. Monthly summaries of the number of degree-days below a base temperature of 65° F are prepared regularly during the heating season for 40 principal cities in Canada.

General Summaries of Hourly Weather Observations in Canada are published annually for 150 main and auxiliary airports and first-order meteorological stations in the country. These Summaries are published on a monthly basis and are directed towards aviation requirements for weather data. They contain frequency information on ceiling, visibility, wind, cloud amount, obstructions to vision, and weather.

As a service to agriculture in Western Canada, weekly summaries of temperature and precipitation for about 175 stations in the Prairie Provinces are prepared and distributed by the Winnipeg office during the crop season, 1 April to 30 September. In addition to the publications issued by the Meteorological Division, Climatological Services also prepare a number of special tabulations of weather data for inclusion in other federal or provincial government publications.

Climatological Services handle each year about 1,600 individual requests for climatological information and advice. Many of the inquiries can be answered by supplying printed reports, summaries, or charts, which are available for such purposes. The requirements for information range from requests for weather data to settle wagers, to the preparation of a section on climatology and meteorology for the *Atlas of Canada* to be published in connection with the most recent Dominion census. Aviation interests have need for frequency data on bad weather conditions at airports and terminals in connection with the assessment of past operations and future planning. Nearly 1,000 inquiries are received annually from manufacturers, agriculturists, transportation companies, tourists, prospective settlers, and others, regarding data or advice concerning climatology.

Quality Control and Tabulation Section of punched card unit showing Electronic Statistical Machines and Sorters.

Numerous requests come from other government departments including the Department of National Defence for information and advice for planning special projects and new undertakings.

It was decided in 1950 to introduce a machine program in Climatological Services, beginning on a very modest scale and gradually expanding the program to embrace all the activities in the Section. In August 1951 a small staff of five machine operators began the transfer of hourly weather observations to punched cards. This staff has been augmented gradually until there are now 18 employed in the processing of current meteorological reports by machine method. Some 6 million weather observations for Canadian stations have been transferred to punched cards. A quality control is performed by machine on all punched cards and punching or observing errors are detected by this procedure. Observing errors are drawn to the attention of the observers and this has resulted in a definite improvement in the overall observing procedures in the field.

All hourly and synoptic weather reports are being currently transferred to punched cards, and it is expected that in the near future, upper-air data, records from climatological stations, and hourly wind and sunshine records will be processed by machine methods on a current basis. The implementation of the complete machine program will facilitate the checking of reports and the publication of the data more promptly than has been possible in the past.

For a representative sampling of weather data for research and special investigations, a period of at least ten years' observations is considered essential. In order that such a period of records might be made available on punched cards at an early date, a program of transferring the data to cards for earlier years was launched in 1954. A staff of 20 was authorized for this project, and during the first year 2 million additional observations were transcribed to punched cards.

All Canadian meteorological reports are photographed on 35 mm. microfilm before going into the archives for permanent storage. The microfilm is available for international exchange; and since it is stored separately from the original records, the loss of original information through fire or disaster is mitigated.

Owing to the vast extent of Canada and its wide range of latitude and elevation, the country experiences a wide range of climates. Studies of the various aspects of the climate are continually in progress. Extensive summaries giving mean temperature, humidity, precipitation, sunshine, and wind for selected meteorological stations in Canada have been published along with several reports on the climate of the country. Recently Climatological Services collaborated with the Division of Building Research, National Research Council, in the preparation of a section on climate for the revised National Building Code for Canada. *A Climatological Atlas for Canada* was issued as a supplement to the climate section of the Building Code. It is interesting to note that it is the first time any national building code has recognized the effect of climate on building to the extent of including a special section on climate in the Code.

At present Climatological Services are engaged in preparing a series of more than 60 climatic maps for inclusion in a section on climate in the new *Atlas of Canada* to be published in connection with the 1951 Canadian census. Work is also progressing on studies of frost-free season, snow cover, humidity, and other aspects of Canadian climate. Work is going forward on the computation of normal values of temperature and precipitation for the standard normal period 1921 to 1950.

In addition to the special studies on climate which are being conducted in the Headquarters office of the Division, three meteorologists attached to the Section are assigned to other government departments. Technical assistance is provided to the Division of Building Research, National Research Council, by a meteorologist attached to Climatological Services. Another meteorologist assigned to the Department of Agriculture in Ottawa is studying the effect of climate on various crops with special reference to conditions in Northern Canada. A third meteorologist attached to the Forestry Division, Ottawa, is studying the effect of climatic influences on forest growth.

Air Delivery of supplies to an Arctic weather station.

The Canadian Arctic

W. Gilmour Clark, *Meteorologist*

MOST of us have fairly strong impressions about the Arctic. The popular conception of that far away land is one of bitter cold, of six months daylight followed by six months of darkness, and of heavy snows and almost constant blizzard-like weather. Stories of the Arctic continually choose such a setting to give the right atmosphere and background. As is so often the case, there is an element of truth in such a picture, but there is also much in the nature of popular "delusions."

The Arctic is a cold land, but the cold is more persistent than extreme. In contrast to the equatorial areas which receive an excess of heat from the sun, the Arctic receives an insufficient amount of heat to maintain its temperature. It must, therefore, continuously export its excess of coldness or be provided with heat from the south. Both these methods are used, but mostly the former, as we are all too often aware.

The explorers who braved the hazards of the Arctic in the hope of finding the famed North-West Passage to the Orient found ice-choked seas and a climate that seemed to present an even more impenetrable barrier.

But tales of the hardy and well adapted Eskimo, the trapper, the fur trader, and of Arctic flowers that bloom in a profusion of color have drawn scientific expeditions in a continuous search for knowledge of this little known land.

The Arctic is the source for much of the chill and frostiness of the north winds that periodically bring sharp temperature drops to Canada and the United States. It is, however, over the vast land areas of the Yukon,

the Northwest Territories, and the northern parts of the Prairie Provinces and Quebec that the air reaches its coldest temperatures. For here, without the moderating influence of water surfaces, the land readily loses its heat and reaches extreme low temperatures. In these latitudes the record for coldness is held by the observing station at Snag, in the Yukon, with 81° F. below zero.

Although the temperature in much of the Arctic does not rise above the freezing point for nine months of the year, in the three month "summer" period quite enjoyable weather is experienced. While the days are never hot, extremes of 55 and 60 degrees are recorded, and since in these latitudes mosquitoes and flies are non-existent, the cool cloudy summer can be fully appreciated.

The Arctic has rather light precipitation. Most of it is, of course, in the form of snow. Total precipitation averages 5–15 inches which is light by Canadian and American standards. Rain does fall in the Arctic, contrary to popular belief, and in three or four of the summer months rain is recorded at even the most northerly weather station, at 82° 30′ north. The Arctic snow is of a granular type which, because of its very nature and the lack of forests and other obstructions, tends to blow with the wind and accumulate into drifts.

The Arctic is not such an area of strong winds as is sometimes reported. The flatness of much of the country leads to a persistence of wind, but extremes at the Arctic stations show lower values than those of places in the temperate latitudes.

An understanding of the periods of daylight and darkness in the Arctic depends on a study of the sun and the effect of latitude. On the 22nd of December, when the sun is shining mainly on the southern hemisphere, its rays do not fall on any part of the earth farther north than latitude 66° 30′. All points north of this latitude do not see the sun at all. However, by March 22nd, the sun's rays reach as far as the North Pole, and areas within the Arctic Circle are experiencing approximately equal daylight and darkness. By June 22nd, the sun is shining principally on the northern hemisphere and, as the sun circles above the horizon, all points within the Arctic Circle have twenty-four hours of sunlight. Then the cycle begins to reverse itself. Even when the sun does not appear above the horizon the effects of dawn and twilight are apparent.

There are about 8,500 Eskimos in the Arctic regions, distributed unevenly and subject to considerable seasonal migration. The white man now lives much farther north than the Eskimos, whose most northerly living areas are in the Mackenzie Valley. Native Indians are not found in the Arctic at all.

During the Arctic summer, the land in some areas is profuse with flowers, mosses, and lichens which seem to spring to life as soon as the snow becomes patchy. It is true that trees do not grow north of a line running approximately from Churchill to Aklavik, for forests persist only where the mean summer temperature reaches 50 degrees. Surprisingly enough, garden crops can be successfully grown in the southern Arctic and bumper crops of certain vegetables have been harvested after a short summer growing season. The longer duration of daily sunshine above the Arctic Circle seems to more than compensate for the lower temperatures, and certain vegetables grow very well indeed.

The Arctic is free of snow for about two months in the summertime and presents generally a barren, rocky terrain, except where thin layers or pockets of soil allow the Arctic vegetation to flourish. Wildlife is more abundant than most people believe. The polar bear, caribou, fox, musk-ox, and rabbit are the most common land animals; walrus, seals, and whales are plentiful in the sea and provide a source of food, clothing, and oil for light.

The great impact of a period of weather dominated by unusually cold air from the Arctic has led the weather services of both Canada and the United States into a determined effort to know the climate of the Arctic, and to have available daily reports on its weather. Through very close co-operation and understanding the two countries have established a network of Arctic weather reporting stations that has crept steadily north until one of them, Alert, is now observing the weather within 500 miles of the North Pole. With the wonders and ingenuity of our modern age, its controlled heat and insulation, its cold weather clothing and air-drop supplies, man has conquered the cold

and successfully braved the rugged climate that beat so many of the earlier explorers.

Canada and the United States operate more than twenty Arctic weather stations and some of them now have a continuous weather record covering several years. Although a great deal has been accomplished and regular weather reports now provide a working knowledge of Arctic weather conditions, much remains to be known of the Arctic climate. Vast Arctic Ocean areas, countless islands, and much of the Arctic land areas have no reporting stations and weather developments in these areas continue unrevealed to the weathermen who study the weather to the north for portents of the future.

With the steady growth of trans-polar flying that now criss-crosses the Arctic, the foresight in establishing a network of Arctic reporting stations is becoming increasingly evident. Not only do these stations stand on guard to warn of weather changes that will bring headline news to the continent, but they act as bases from which scientists are exploring the secrets of the Arctic. Our knowledge of the once "unknown" Arctic is growing steadily as day-to-day regular reports of Arctic weather continue to reveal the broadscale nature of the atmospheric developments over North America, the Oceans, and the Arctic.

History (*Continued from page 41*)

Certain predictions might be made. There will be a considerable expansion in public weather services, with longer range forecasts and a wider variety of services as more and more individuals, associations, institutions, and branches of our economy learn to apply weather advice to advantage. There will be increasing attention to weather control and, after the present exploratory period of experiment and research has set such operations in their proper perspective, carefully planned and controlled large-scale operations will be undertaken to modify those elements of the atmosphere which can be actually and economically altered to our advantage. Our indoor comfort and general health will be much improved through careful study, new knowledge, and closer co-ordination with the changing weather. The application of machine methods to the processing of climatological data will be expanded and will provide a great deal more information in better form to many more users. Industry will apply weather knowledge to much greater effect in its processing, and overall operations will be adjusted to minimize the effects of adverse weather, while taking full advantage of favorable conditions. Despite some advances in long range predictions, calculated risks will be based to an increasing degree on statistical studies of weather records.

The 117-year span of weather service in Canada has seen phenomenal growth from a one-room establishment to a service of 1500 reporting stations and 50 forecast offices; from a budget of $2,000 to $10 million dollars and from 7 employees to 1900 employees. We are confident that the Canadian Weather Service will continue its substantial growth, both in its ability to provide knowledge on meteorological matters and in its capability to meet the anticipated demands of the future.

* * *

No history of the Canadian weather service would be complete without the name of Dr. John Patterson. Ontario-born, he joined the Meteorological Service in 1910, having experienced two years at Cambridge University, England, a professorship in an Indian university, and 5 years as head of the Imperial Meteorological Service in India. In 1929 Dr. Patterson was appointed Controller of the M.S.C. and continued in this capacity until his retirement in 1946. An outstanding physicist and mathematician, he made many contributions to the science of meteorology, particularly in the field of instrument design. Of Dr. Patterson, who died on February 22nd of this year, Commander Reichelderfer said recently: "His sterling leadership and his outstanding role in international co-operation and standardization within international organizations are recognized throughout the world."

Weatherwatch

An Interesting Mid-Winter—1955–56

DAVID M. LUDLUM, *Editor*

The winter of 1955–56 added to the series of spectacular weather events that have marked the progress of the decade of the 1950s. In North America the season commenced with a record-breaking early cold spell in mid-November in the West and with the coldest November in years generally throughout the Middle West and East. As the season drew to a close in March, mighty snow storms blanketed the Northeast with a record March covering, and in the Far West snow accumulations approached new totals. The continent of Europe experienced its bitterest, prolonged winter weather of the present century in February with unprecedented cold in the central portions of the continent and the deepest snows in memory in Mediterranean areas.

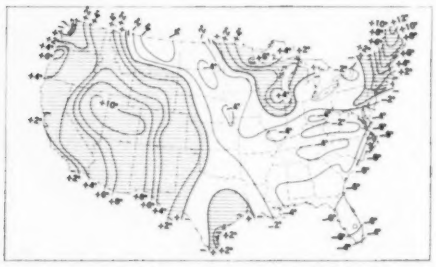
The factors underlying the current trend to abnormality are not hard to find from an inspection of the mean upper-air maps for January and February. These, however, merely reflect the state of the atmospheric conditions and do not explain why there has been a tendency to the unusual in meteorological matters of late. There have been many explanations brought forward by scientists and others, but no one reason has received general acceptance.

The upper-air maps show us that intense and persistent blocking of the normal movement of air from west to east prevailed over North America from late October to late February without any considerable break. The principal block appeared over northeastern Canada and Davis Strait where pressure was far above normal, a continuing feature of the weather maps throughout most of 1955. The blocking effect of this great ridge of high pressure reversed the usual upper-air flow across North America and moved storm tracks far from their normal course. Easterly winds, usually the rule in the polar regions, appeared in middle latitudes; their effect was dramatically shown by the extremely mild January in Maine and the Maritime Provinces—the mercury averaged 12 degrees above normal at Caribou as Atlantic air flowed inland and excluded continental influences.

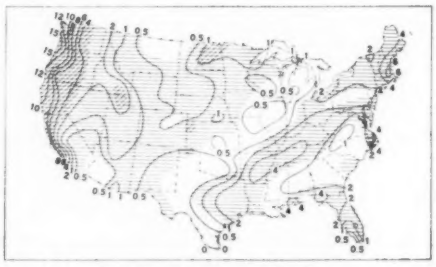
The pressure contours aloft showed two well developed troughs off both the Atlantic and Pacific coasts with weak ridge conditions prevailing over the Rocky Mountains and Plains area. The blocking anticyclone over northeastern Canada steered storm tracks from their normal course. The usual route up the St. Lawrence Valley was almost unused by depressions. Instead the trough off the Middle Atlantic coast was a mecca for storms which formed either in the Gulf or over the Southeast and then moved northeastward offshore and south of Newfoundland.

THE GREAT ATLANTIC LOW—The index of westerly flow reached its all-time low for this period of the year, and for any period, on 7–11 January 1956. A glance at the surface weather map for these days reveals a very unusual situation. Just off the Middle Atlantic coast a deep, almost stationary, low was found with a central pressure on the 9th below 29.00 inches. Directly to the north

MONTH OF JANUARY 1956



Departure of Average Temperature from Normal in degrees Fahrenheit. USWB chart.



Total Precipitation in Inches. USWB chart.

over extreme northern Quebec an anticyclone of great magnitude was located with a central pressure reported above 31.40 inches, the highest pressure ever noted in that region. Remarkable meteorological events proceeded from the juxtaposition of these two features. Moist maritime air from the mid-Atlantic was impelled westward in the circulation between the high to the north and the low to the south. A warm front developed as the maritime air pushed westward displacing the cool, continental air.

Precipitation, both liquid and solid, developed in the contrasting air masses and spread gradually westward, but the zones of different type precipitation were orientated longitudinally rather than along the usual lines of latitude. Snow, sleet, freezing rain, and then rain spread in succession from the coasts of New England and Canada westward as far as Illinois and southward as far as southern Virginia, as the great Atlantic low continued to hold position for nearly a week and to dominate air flow over half the continent. The great spiral of winds to the west and south of the low brought a flow of cool, dry air down over the Southeastern states. A complete reversal of the usual order of things in temperature zones was set up. For the week ending 15 January, northern Maine's temperature averaged 24 degrees above normal, while points in central Florida had readings 15 degrees below normal. From 8 to 14 January the mercury did not dip below freezing at Caribou, the northernmost weather station in eastern United States, while Florida had nighttime readings below freezing most every night during this period.

The Great Atlantic Low of early January 1956 appears to have been without a parallel in recorded weather history. No such occurrence appears in the series of historical weather maps which commence in 1899. Boston in this period recorded the greatest number of consecutive days with precipitation since 1871 when records commenced. A search further back reveals a period in January 1836 when northeasterly or easterly winds prevailed without break from 4 to 11 January followed by five days of west or northwesterly flow. Weather maps for this period, of course, are not available, but it does indicate an air flow pattern similar to January 1956.

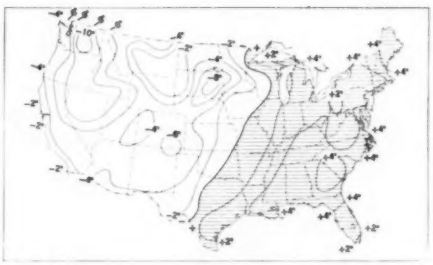
The temperature regime for January shows the marked influence of the two offshore troughs. In the Far West and Rockies, it was a very warm January, as it was in the Northeast. In most central sections and in the South it was a cool to very cold January as continental air flow dominated over the central ridge. The warm areas were wet, too, as maritime air moved inland over cool surfaces. There was a large dry area stretching from Texas to the Upper Lakes, due principally to the southeastward displacement of the usual cyclonic tracks for the month.

FEBRUARY—The atmosphere around the northern hemisphere underwent a rather sudden and decided change at the very end of January. A new distribution of ridges and troughs caused a sweeping change in the general circulation. A rather weak-looking ridge, which prevailed in the mid-Atlantic during January, suddenly displayed great energy and built northeastward to the west of the British Isles at the close of the first month, and ultimately stretched into the sub-Arctic. Another strong block was set up, and Europe's usual maritime climate was replaced with a continental variety.

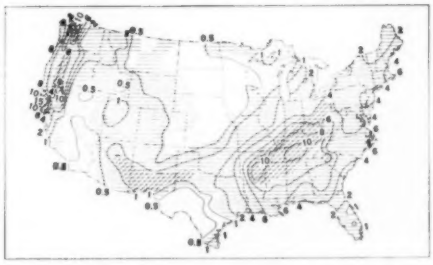
The blocking ridge off the British Isles had an important extension northeastward over Scandinavia. This stimulated the development of low pressure in the Mediterranean area and an ideal situation for the movement of Arctic air from Siberia into all of Europe was established. Cold easterly winds swept westward bringing snow to regions that seldom experience heavy falls. In central Austria the mercury averaged 24 degrees below the February normal, and even in Spain, almost surrounded by warm water, the readings were 12 degrees below normal for the month. With moisture supplied by the low in the western Mediterranean, heavy snows fell over southern France and Italy. Rome had its deepest snows of recent record.

In North America the shift in circulation was pronounced, but did not produce such abnormalities in

MONTH OF FEBRUARY 1956



Departure of Average Temperature from Normal in degrees Fahrenheit. USWB chart.



Total Precipitation in Inches. USWB chart.

the weather. Though a low index of westerly flow continued, the weather maps for February wore a more normal look. The pressure distribution over the United States was almost the reverse of that of January: ridges appeared off both coasts and a trough occupied central sections from the Upper Lakes to New Mexico. Pressure averaged below normal over all of the West. A polar low in Canada drew cold air down into the Plateau regions to reverse the temperature readings of the previous 30 days. The eastern ridge off Florida had the appearance of a summer high and drew southerly air over the Southeast and Middle Atlantic states for the first above normal month of the winter. From Lake Michigan to Texas, in the valley of the trough, temperature conditions were nearly normal as cold air and warm air changed places periodically.

A TRANS-CONTINENTAL STORM—It is not unusual toward the close of winter or in early spring, when there is a good contrast of air masses present, for a single cyclonic disturbance to cross the entire continent and to produce a grand variety of weather events from the Pacific to the Atlantic. Such a storm entered the Pacific Coast on 22 February with a very complicated frontal system developing as ocean air met the barrier of the coastal mountains. A preceding disturbance had hovered off the coast on the 19–20th, commencing a series of heavy orographic rains that the second low intensified. Rainfall from 19–23 February at Hobergs in California totaled 19.32 inches. The areas of northern California and southern Oregon which experienced disastrous floods in December again felt high water, and flooding occurred on the Russian and Eel rivers, though this time much of the fall in the higher mountains was in the form of snow, reducing the immediate runoff.

The complicated frontal system sprawled across the Plateau and Rocky Mountains on the 23rd without a definite center discernable, but by noon of the 24th a circulation had formed on the Colorado-Kansas border and pressure began to fall on the Plains. A warm front extended northeastward to Chicago and then southeastward to Knoxville, dividing the nation into two thermal zones, always a good precursor of stormy weather. Snow spread across the northern Plains with much drifting, and in the South dust began to blow. Early on the 25th a marked cold front had progressed to the Lake Michigan-St. Louis-Ft. Worth line, and soon afterwards tornadoes occurred in central Illinois and did considerable damage. The cold front rushed quickly eastward on the 25th: by noon it had reached Pittsburgh and by 1930 had cleared the Atlantic coast. Very high southerly winds swept the Appalachian regions before the front, and westerly gales followed. By midnight the center had passed northeast of Quebec City with a central pressure near 28.60 inches.

Forecasting (*Continued from page 55*)

meet individual requirements when the routine aviation forecasts are inadequate.

Within the area there may be one or more Aviation Forecast Offices responsible for looking after local requirements. The A.F.O. uses weather maps received over a national Weatherfax system from the Central Analysis Office in Montreal and from its parent forecast office. Forecasts and weather reports are received over the meteorological teletype system. An A.F.O., whether it be set up as mainly a civil or a military office, has the responsibility of tailoring its weather advice to meet the particular needs of the individual user.

At a forecast office, pilots receive on-the-spot briefing. This includes direct reference to the latest weather maps and aviation forecasts, and the advice of a professional meteorologist in flight planning. The forecast offices are located mainly at the larger airports. At other airports and intermediate landing fields, however, weather observing stations and radio-range stations keep watch on the weather. Most of these stations are connected to the meteorological teletype system and can assist the pilot with the latest forecasts and weather reports. When the information at these intermediate stations does not meet all the needs of the pilot, or when the weather situation seems to demand the professional advice of a meteorologist, the pilot may request a flight forecast from the nearest District Aviation Forecast Office by telephone, telegraph, or teletype.

To enable the Canadian pilot to make intelligent and full use of the weather services and develop an appreciation of Canadian weather, the M.S.C. runs extensive training programs. Many meteorologists at RCAF schools are continuously employed in training large numbers of student and veteran pilots in meteorology and weather service.

Similarly in the civilian field, the M.S.C. sets the meteorological examinations for all pilots and navigators, a practice which is carefully designed to ensure a high standard of knowledge of weather and weather services.

Aviation has a large part to play in Canada's future. The Meteorological Service of Canada will continue to play an important supporting role.

DAREX meteorological balloons at work . . .

DURING THE INTERNATIONAL GEOPHYSICAL YEAR, the world's scientists will extend their knowledge of the far reaches of the upper atmosphere. From new stations—and chains of stations stretching from pole to pole and around the world—intensive and simultaneous studies will be made of solar radiation, cosmic ray, aurora and airglow phenomena.

Dewey and Almy, as the world's largest manufacturer of meteorological balloons, will play an important part in these aerological studies. DAREX balloons have been developed to meet the special requirements of the many phases of atmospheric research. Included are sounding balloons for recording weather data up to 120,000 feet—night-flying balloons to 100,000 feet—tandem-rigged balloons for carrying aloft loads of 75 pounds and more—Kytoon (captive) balloons for lower altitude research.

Characteristics of three of the specialized DAREX balloons scheduled to take an important part in I.G.Y. research are:

Weight.....	1750 gms.	2400 gms.	7000 gms.
Min. Burst Diameter.....	24 ft.	29 ft.	52 ft.
Gas Volume at Sea Level (helium).....	148 C.F.	171 C.F.	400 C.F.
Altitude (with normal load).	100,000 ft.	107,000 ft.	120,000 ft.

Because of the high degree of extensibility, DAREX neoprene sounding balloons provide a means of reaching maximum altitude at minimum cost.

If you are planning special atmospheric studies during the International Geophysical Year, let us know of your requirements. Our engineering staff is well qualified to help you.

DEWEY and ALMY
Chemical Company
DIVISION OF W. R. GRACE & CO.
Cambridge 40, Massachusetts • Montreal 32, Canada

. . . since 1935, leading makers of:
captive balloons • pilot balloons
kite balloons • sounding balloons
inflation kits

Meteorological Instruments

H. H. BINDON

Assistant Controller—Instrument Services

FROM the very start, the Canadian Meteorological Service found itself in one unexpected situation after another. The early observers were ardent weathermen at heart, but the grandeur of the scenery in the new colony also produced an endless variety of daily weather that offered a hard challenge to the early weather observing instruments.

The instruments brought over from England had been designed for a less rigorous climate, and it was soon found that they were no match for the elements they were to record. All too often the mercury froze in the thermometers. But the young weather service grew and expanded to the west and the north, and found itself constantly challenged by the need for improved instruments adapted to the rigors of a climate of extremes.

Not only must the equipment withstand wide extremes of heat and cold, but also the salty gales of the coasts and the dust of the prairies. Isolated stations were seldom inspected and faulty instruments gave inaccurate readings or none at all. Batches of imported instruments suffered the inevitable fate of heavy handling and arrived in a sadly damaged condition. Local instrument makers showed little or no interest in small orders with big design problems.

In the face of such difficulties the only solution open to the Meteorological Service was to produce its own instruments. And so it was in 1928 that an Instument Section was formed and a small shop was built and equipped behind the Toronto Head Office. As the demands increased, the new Section expanded and became more effective and adaptable. Each year saw new developments and new designs as ever more reliable and sturdy instruments were produced, serviced, inspected, and in turn replaced by more serviceable types.

The Instrument Shop soon opened new departments, a carpentry-woodworking shop and a clock-making section. J. Patterson, former Controller of the Canadian Service, developed the fixed-cistern barometer, portable, rugged, accurate, ideally suited for the job. Carefully fashioned, every scale, bolt, and thumbscrew was hand made, so that these barometers are now the standard type throughout Canada. Other observing instruments, the Canadian radiosonde and the barograph, the three-cup anemometer, and the flashing light indicator, were made in quantity but always seemed in short supply.

Working as it has in close touch with field problems, with numerous reports on field servicing, and constant study of instruments under repair, the Instrument Section has been able to develop a high degree of standardization. Interchangeable parts and easy reading instruction books keep the out-of-order periods to a minimum. Defects that show up under rugged weather service are soon brought to light, investigated, and corrected.

Many unique instruments have been developed by the designers on the staff. A brief description of two or three of these may be fitting here. The Patterson barometer is made in such a way that the volume of the cistern can be reduced by compressing a leather bag. The mercury is forced up to fill the barometer tube eliminating all splashing and pumping of the mercury during transport. Not only is the danger of breakage greatly reduced while moving the barometer, but the possibility of air being introduced above the mercury column is greatly reduced.

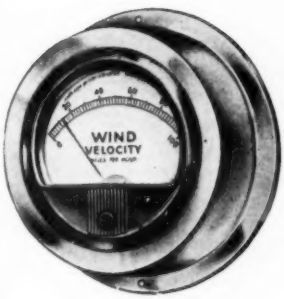
The Canadian rawinsonde is of the chronometric type, in which the contacts for temperature pressure and humidity are spaced over a 13-second time cycle. Mechanical arms activated by the three measuring elements make contacts as their three pointers glide over a rotating, flat, plastic, circular disc in which a spiral metal ribbon is imbedded. The disc, rotated by a tiny electric motor, turns at a uniform speed controlled by a reed-governor of special design. As the pointers in turn make contact with the metal

spiral, the emission of a 403 m.c. single-tube radio transmitter is momentarily interrupted. Each complete rotation of the disc is clearly indicated by two fixed reference contacts. The signal is received at the ground by a radio-theodolite which determines the velocity of the upper winds by tracking the radiosonde, and feeds the interrupted signals to a simplified chronometric recorder which graphs the pressure, temperature, and humidity.

The measurement of humidity at low temperatures is difficult yet important. An automatic dew and frost-point recorder has been designed which gives considerable promise for improved humidity observations especially at Arctic stations. In this instrument a sample of the free air is blown in a jet across a cooled button. The button is cooled by a small, commercial refrigeration unit. As frost forms on the button, it is detected by a germanium photo-cell which activates a magnetic valve. When the valve opens, a small quantity of heat is projected to the underside of the button from a jet of hot gas, thereby removing the dew or frost. The hot gas is drawn off the warm, high pressure side of the refrigeration unit. The temperature of the button is made to "hunt" about the dew point, and this temperature is measured by means of a small thermistor which is imbedded just below the frost surface of the button.

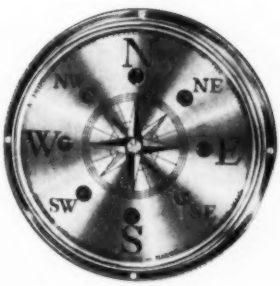
WIND INSTRUMENTS

No. 410. Wind Speed Indicator.



Three-cup anemometer is mounted out-of-doors and registers speed of wind directly in miles per hour on an indoor indicator. The 4-inch polished brass dial registers up to 100 mph. Spinning cups generate a small current which is measured on the volt-meter indicator. No external power source is required. Anemometer is connected by low voltage 2-conductor No. 22 wire. Diameter of cup rotor is 10″. Height of pipe support is 12″. Complete, ready for installation and operation, with 50 feet of wire. Wt. 4 lbs. **$50.00**

No. 411. Wind Direction Indicator.



A small wind vane is mounted out-of-doors and transmits wind direction to eight compass points on an indoor indicator. The vane has eight built-in contacts which complete an electrical circuit to the indicator. The vane assembly is connected by 9-conductor cable to the eight lamps of the indicator. The proper lamp flashes for the current wind direction. Dial measures 7½″ in diameter and ¾″ deep. Operates on 110 v. A.C. current. Outdoor support 12″ high. Complete with 50 ft. of cable. Wt. 4 lbs. **$50.00**

Science Associates

194 Nassau Street **Box 216** **Princeton, N. J.**

An Introduction

(*Continued from page 39*)

these stations should flow across the boundary without any interruption whatsoever.

The U. S. Weather Bureau and the Meteorological Service of Canada have somewhat different historical backgrounds. The M.S.C. traces its development back to Christmas Day in 1839. On that day the first weather observations were taken near the present headquarters office in Toronto by members of the staff established by the British Ordnance for terrestrial magnetism and meteorology. The U.S.W.B. developed largely from the requirements of the post-Civil War period through the agency of the U. S. Signal Corps. During the intervening years each has passed from one government department to another and each has been organized and reshaped to meet growing demands for meteorological services. Today they do much the same work. You will discover from an article on our Basic Weather Service that, by way of example, we rely on a great many volunteer weather observers in Canada just as you do in the United States. You will learn from an article on our Research Department that we are concerned with and working on much the same meteorological problems as you are. You will find that in Climatology we have gone over to the machine age and are putting all our weather records on punched cards. The similarities between the two services will be immediately obvious to you. There is really only one major difference between the work of the two services—the Canadian Meteorological Service provides weather service for the Royal Canadian Air Force, Navy, and Army, whereas in the United States each of the Armed Services has its own weather organization.

I know that this issue will give you a greater understanding of Canada and of her meteorological activities in particular. I hope that from reading of our country, its climate, and its Meteorological Service you will want to see and experience our Canadian weather at first hand. May I add my personal invitation to you to visit Canada whenever the opportunity presents itself and in particular to visit any of our weather offices where, I can assure you, you will be most welcome.

Climate

(*Continued from page 57*)

In the inland valleys, although rainfall is very light (averaging ten inches) and would be insufficient for agriculture, the melting snow from the mountains and widely practiced irrigation lead to near ideal fruit-growing conditions. The Okanagan Valley is widely known for the excellence and variety of its abundant fruit crops.

It is only natural that the people of Canada and those of the United States should feel some concern over the climate of each other's country. Our seemingly unlimited exchange of commodities across the border, so widely applauded as a model of co-operation, also includes what seems to be an export of unwanted weather. In the winter, frigid "Canadian" air pours deep into the United States, and in the summer hot sticky air from the United States settles over eastern Canada. Although, meteorologically speaking, these are polar and tropical air masses, one thinks of these 'weather invasions' as typical of the other country's climate. On the other side of the ledger are the many welcome respites when southerly winds break the prolonged Canadian cold spells, and northerly winds bring temporary cooling relief to the United States after days of heavy heat.

The press is forever alert to highlight today's weather as the worst storm, the heaviest snowfall, or the most prolonged heat wave since records began. Since weather records are relatively young for many of our observing stations, it is inevitable that over the years new records for the day, or the week, will continue to be made for years to come. Weather is often justifiably headline news and the frequency with which the weather and climate are featured in story and picture ably justifies Canada's reputation for a climate of wide variety and constant interest.

This brief note on Canada's climate will, it is hoped, simply entice the reader to obtain more detailed information on the weather across the border and, perhaps, to join the flow of tourists that yearly go in increasing numbers across that border to explore the other country and its weather, seeking a new experience in the distant fields of an unexplored climate.

4

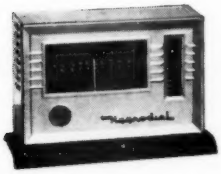
BENDIX-FRIEZ*
WEATHER INSTRUMENTS
FOR
AMATEUR AND PROFESSIONAL USE

ANEROID BAROMETER

Here's high accuracy at a low cost. Has sensitive aneroid element. Temperature compensated from 27.5″ to 31.5″. Scaled in inches and millibars. Gold aligning pointer for back reference. Available in attractive brass or chrome case. 5½″ dia. Use indoors or out.

PSYCHROMETER Model HA/2

This Hand Aspirated Psychrometer gives quick, accurate readings. Compact. No whirling. Has two identical 5″ red reading mercurial thermometers with cylindrical bulbs. Graduated from 10°F. to 110°F. One degree spacing. Widely used by meteorologists.



HYGRODIAL Model 187

Gives automatic readings of humidity and temperature. Manufactured and calibrated to professional standards. In handsome plastic case. For desk or wall mounting.

"POCKET" SLING PSYCHROMETER Model S/1

No weather kit is complete without this "Pocket" Sling Psychrometer. Portable. Versatile. In durable, leather-covered aluminum case. Complete with convenient Psychrometric Slide Rule.

Write today for information and prices. Your inquiry will receive prompt attention.

* Reg. U. S. Pat. Off.

Bendix - Friez

FRIEZ INSTRUMENT DIVISION—BENDIX AVIATION CORPORATION
1412 TAYLOR AVENUE — BALTIMORE 4, MARYLAND

Export Sales and Service: Bendix International Division, 205 E. 42nd Street, New York 17, N. Y., U.S.A.

North Magnetic Pole
Arctic Weather
95°F in June
-81°F coldest
N O R T H W E S T T E R
Eskimo
YUKON
BRITISH COLUMBIA
Mounties
103°F in July
Totem
ALBERTA
SASKATCHEWAN
MANITOBA
Lumber
Oil
Chinooks
115°F hottest
Wheat
Cattle